UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
WASHINGTON, D. C.
H. H. BENNETT, CHIEF

ADVANCE REPORT

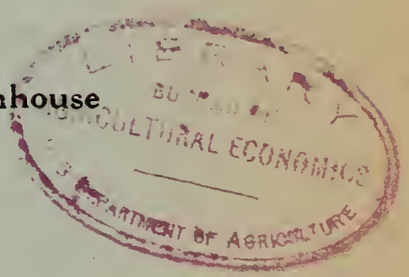
on an

INVESTIGATION OF SILTING IN THE YORK RIVER, VIRGINIA

October 25 - November 5, 1938

by

Carl B. Brown, Louis M. Seavy, and Gordon Rittenhouse



Sedimentation Studies
Division of Research
SCS-SS-32
March 1939

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Washington, D. C.
H. H. Bennett, Chief

ADVANCE REPORT

on an

INVESTIGATION OF SILTING IN THE YORK RIVER, VIRGINIA

October 25 - November 5, 1938

by

Carl B. Brown, Louis M. Seavy, and Gordon Rittenhouse

Sedimentation Studies
Division of Research
SCS-SS-32
March 1938

ABSTRACT

During the fall of 1938 a study of sedimentation in the York River estuary between West Point and Gloucester Point, Va., was made by the Section of Sedimentation Studies, Division of Research, Soil Conservation Service. The water depths in 1938 were compared along 13 ranges across the estuary with water depths in 1857, 1911, and 1918 as shown on U. S. Coast and Geodetic Survey charts, and the amount of fill, or scour, was computed.

Results of the investigation show that from 1857 to 1911 the net accumulation was 5,591 acre-feet, or 104 acre-feet per year; from 1911 to 1938, 15,293 acre-feet, or 566 acre-feet per year. The annual rate of accumulation during the latter 27-year period was more than five times the rate during the preceding 57-year period from 1857 to 1911. Accumulation was most rapid in the section of the river from 5 to 11 miles below West Point. Comparison of the 1857-1911 and 1911-1938 data indicates that there has been a downstream migration of the locus of most active sediment deposition.

The deposits are dominantly gray silty clay. No definite horizon was identified which might be considered the bottom of the estuary at the time culturally accelerated erosion began in the tributary drainage area. Samples of the deposits were collected but have not yet been analyzed.

Pertinent data on sedimentation and dredging operations, as presented in the annual reports of the Chief of Engineers, U. S. Army, are summarized.

INTRODUCTION

An investigation of silting in the upper part of the York River, Va., was made by the Section of Sedimentation Studies, Division of Research, Soil Conservation Service, during the period October 25 - November 5, 1938.[1] The objectives of this investigation

---

[1] The field survey was made by Louis M. Seavy, assistant civil engineer, with the aid of helpers and a boat generously furnished by the Chesapeake Corporation of West Point, Va. Sediment examinations were made in the field during a period of two days by Gordon Rittenhouse, assistant geologist. The studies were planned and this report was prepared by Carl B. Brown, geologist, assisted by Gordon Rittenhouse and Louis M. Seavy.

were to determine (1) the amount and rate of silting in the York River by comparison with previous surveys, (2) the character of sediment on the bottom, and (3) any apparent relationships between sedimentation and causative factors.

The investigation consisted of (1) soundings taken along 13 ranges across the York River within a distance of 20 miles downstream from West Point, Va., (2) field examination of sediment samples secured with a silt-sampling spud and coring pipe, and (3) collection of sediment samples for analysis.

This preliminary report is confined largely to the results of studies of comparative survey data. It is probable that some additional information can be obtained from a further study of the cross sections, graphs, and charts. More detailed descriptive material on the character of the river bottom at various places could be compiled from field notes and columnar sections, but such information does not appear to bear a significant relationship to other phases of the investigation. The preliminary investigation indicates that much more extensive studies would be required to determine conclusively the relationship between sedimentation and causative factors.

DESCRIPTION OF AREA

The York River drainage basin (fig. 1) is in the northeastern part of Virginia between the Rappahannock River basin on the north and east and the James River basin on the west and south. The total area drained by the York River and its two main tributaries, the Pamunkey and Mattaponi Rivers, is 2,660 square miles, of which 2,371 square miles is above West Point, Va. The drainage area directly tributary to the York River below West Point is 289 square miles. The entire drainage basin, from the mouth of the York River to the headwaters of the Pamunkey and Mattaponi, is 122 miles long and from 9 to 42 miles wide.

The York River has a total length of about 40 miles and is formed by the junction of the Pamunkey and Mattaponi Rivers at the town of West Point. It is entirely a tidewater stream. In fact, tidal flow extends above West Point for 60 miles in the Pamunkey and 38 miles in the Mattaponi. A good general description of the natural characteristics of the York River and its drainage basin may be found in the report of the Virginia State Planning Board.[2]

---

[2]Vol. 2, Dec. 31, 1935, pp. 62-88.

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
H. H. BENNETT, Chief

YORK RIVER
FROM WEST POINT, VIRGINIA TO YORKTOWN, VIRGINIA

SEDIMENTATION SURVEY OF OCTOBER 25, TO NOVEMBER 25, 1938

10,000 0 10,000 20,000 30,000
Scale in Feet

LEGEND
—R-5— Silt Ranges
(9) Segment Numbers

Louis M. Seavy, In Charge of Field Survey

Revised 2-14-39

R-2445 12-22-1938

The York River is in reality a part of Chesapeake Bay. It is a brackish-water tidal estuary, remarkable for its straight course and, in general, for the length and depth of its channel. Tidal estuaries of this type are geologically favorable, in fact, normal, locations for deposition of erosional debris brought down from tributary land areas. The only offsetting factors to their complete filling in comparatively short periods geologically are the effect of tidal and flood currents in sweeping sediment out to larger bays or the ocean, and diastrophic movements involving sinking coast lines which increase the water volume of estuaries despite progressive silting.

The normal tide range in the York River is about 2.8 feet at West Point. On October 13, 1893, in one of the severest storms on record, the tide rose to a height of 6.4 feet. Tidal currents require about two hours to move up the 40-mile length of the river. The low-water discharge into the York River at West Point is about 250 cubic feet per second, and the high-water discharge is about 75,000 cubic feet per second.

The investigations discussed in this report were confined to the upper 20 miles of the York River extending from West Point, Va., downstream to within about 6 miles of Gloucester Point. The distance between the uppermost and lowermost ranges used for sediment measurements was 19.41 miles. The average width of the estuary in this section is 9,000 feet.

PREVIOUS INVESTIGATIONS

Previous investigations of silting in parts of the York River estuary have been made by the U. S. Army Engineers in connection with a navigation project. The data from these investigations are largely qualitative and relate principally to the effect of silt deposition in channel bars on the maintenance of a navigable channel.

The original project for improvement of navigation facilities in the York River was authorized in the River and Harbor Act of June 14, 1880. It provided for dredging of a channel 22 feet deep and 200 feet wide through the bars at Poropotank[3] and West Point and increasing the width at the wharves at West Point. In 1884, on account of increased trade, the project was modified by increasing the width of the proposed channel to 400 feet. In 1887, the project was

---

[3]Spelled "Potopotank" in earlier reports of the Chief of Engineers, U. S. Army.

again amended to include the construction of a dike along the right (southwest) bank of the river at the West Point bar in order to prevent the deposit of sediment in the channel.

By 1899 the project was about 75 percent completed; the part not completed was the dredging of the channels to the full project width of 400 feet. This was not considered necessary at that time nor since, owing to decreasing use of the river for navigation after about 1890. A pile and timber dike 10,142 feet in length was built at West Point prior to 1899 and channels aggregating 2.5 miles were dredged and redredged. The total material excavated amounted to 1,296,805 cubic yards. Subsequent dredging has brought the total amount of material excavated to 1938 to 1,600,651 cubic yards (992 acre-feet). The total cost of the work to this date was $335,361.50, of which $82,206.46 was for maintenance from March 1899 to the end of the fiscal year 1929. The cost of the dike constructed to prevent the deposition of sediment in the dredged channel was approximately $52,800. The latest approved estimate for annual cost of maintenance of a navigation channel is $5,000.

Notes on Silting

The following notes on silting are taken from annual reports of the Chief of Engineers, U. S. Army.

In 1880, before the improvement project was started,

> obstructions to the free navigation of the river by vessels of large draught were to be found, first, at West Point, where a sand bar had been formed entirely across the channel and extending a mile or more down the river; and, secondly, opposite Potopotank Creek, distant from West Point about 9 miles, where several sand lumps have been formed in the channel.... Both bars are composed principally of fine black sand, blue mud, and broken shells; and from the fact that but slight changes have occurred on the bars for the past 20 years, it is evident that their formation has been the work of years, and should a channel be cut through them it would no doubt partake of a permanent character.

In 1885 it was reported that

> no exact estimate can be given of the silting of the channel which occurs at the confluence of the Mattaponi and Pamunkey rivers. The amount of silting is now being observed. A plan will be submitted for preventing injury to the channel from this cause, as soon as the data relating to the subject can be collected.

The report for 1886 describes the dumping ground for material dredged from the river as extending "from below Goff's Point to 1,200 feet below Golder's Creek." The dredged material was being deposited on shoals or banks where depths at low water ranged from 3 to 7.5 feet.

The report for 1887 states that "the dumping ground begins at a point on the east side of the river, about 800 feet below Golders Creek, and extends downstream for a distance of about 3,000 feet." These dumping grounds were likewise shoals or banks. In addition to the dumping grounds specifically mentioned, it was reported that some dredged material was deposited on other shallow tidal flats adjacent to the dredged area.

In the same report the Chief of Engineers recommended, as a result of observations over a period of 6 years, that a dike be constructed to prevent silting of the channel. He reported that surveys made to date had not been sufficient to determine the amount of silt annually deposited at and below the junction of the Mattaponi and Pamunkey Rivers, but that each year since 1880 a small quantity of silt had been deposited in the channel. The accumulation brought in by the two streams could not be distinguished from the quantity which flowed into the dredged channel from its sides (by slumping). Measurements showed that material which had been deposited in, or had flowed into, the channel during 1886 was unequally distributed over a distance of 8,800 to 9,200 feet. The greatest depth of deposit was about 3 feet.

With regard to the effect of currents, the Chief of Engineers reported that

> the observed velocity of ebb was 1.91 feet per second, and the velocity of flood was 1.11 feet. Both ebb and flood currents leave the channel where the river widens and make a convex bend in the bay-like area between Ferry Creek and Fillbate's Creek (approximately 450 to 12,500 feet below West Point). The quantity of deposit is greater above the confluence of the ebb currents of the two rivers, and also above the divergent point of the flood currents of the same streams. This confluence and divergence cannot be prevented, but they can be transferred to a lower and deeper part of the channel. The advantage to be gained by this transfer is an increase in the length of the period during which the silting will occur, and consequently a longer interval before it will be necessary to resort to the dredge to remove the obstruction to navigation.

In 1890 it was reported that

> since the commencement of the work at West Point in 1881 it has been necessary to redredge 152,595 cubic yards of silting, which was not provided for in the original estimate. This is about one-fifth (nineteen one-hundredths) of the whole amount dredged at West Point.

From 1890 to June 1893 it was necessary to redredge 95,173 cubic yards, bringing the total amount of material redredged to 247,768 cubic yards.

In 1894 it was reported that

> under a modification of the project by the Secretary of War, January 4, 1889, a cut of 40 feet wide and 24 feet deep was dredged near the center of the channel from the lower wharf at West Point to the second turn in the channel. In January 1890, the ruling depth in this cut had been reduced by silting to 20.6 feet and in the rest of the channel to 19 feet.
>
> A survey of the West Point Bar was made in September 1892, and test piles driven near the proposed line of dike. The survey showed a ruling depth of practically 20 feet, and indicated that the shoaling still continued.

In 1931 it was reported that "the channels are in fair condition and considered adequate for the present navigation." Controlling depths ranged from 20 to 22 feet.

The dike had largely disintegrated by 1938, only a few piles being still visible.

METHODS OF 1938 INVESTIGATION

Field investigations by the Soil Conservation Service in 1938 consisted of three parts: (1) Soundings on 13 ranges to record present water depths for comparison with those indicated on older maps, (2) field examination of sediment brought up by a silt-sampling spud and auger, and (3) collection of samples. In addition, a study of old maps and a search of all literature references to the York River have been made in the office.

Sounding Surveys

Maps available for comparison consisted of three sets of hydrographic charts of the U. S. Coast & Geodetic Survey. The first set was based on soundings made in 1857, the second on soundings made in 1911, and the third in part on soundings made in some of the area in 1918 but largely on soundings of earlier surveys.

During the period October 25 - November 5, 1938, soundings were made by the Soil Conservation Service on 13 ranges in the upper 20 miles of the York River. These ranges were located so that the soundings could be compared with those shown on older maps, and so that good visibility and intersection to points on shore could be obtained in making sextant locations.

Soundings were made from a small launch, by means of a marked sounding line and a 5-pound cone-shaped cast-aluminum sounding weight in shallow water and a 9-pound cast-iron weight in deep water. Water depths were recorded to the nearest tenth of a foot. Locations were obtained at three to eight points on each range with a sextant, and the location of intervening points of sounding were interpolated by assuming that the boat traveled at a uniform speed between points of sextant observations. These locations were further checked by recording the position of boundaries of oyster beds marked by rows of poles set in the soft mud bottom. The boundaries of these individual leased areas have been accurately surveyed by the Virginia Commission of Fisheries.

Arrangements were made to obtain quarter-hourly readings on three temporary tidal gages located at West Point, at Allmond's Wharf, about midway between West Point and Gloucester Point, and at Gloucester Point. From these readings depths of water recorded by soundings were corrected to mean low tide.

Soundings along each range were plotted on cross-section paper as a profile from shore to shore. Sounding data from hydrographic charts of 1857 and 1911 were plotted to the same scale and datum so that three cross sections were available for comparison along each range. Sounding data on the 1918 charts are very meager except at ranges 7, 8, 18, and 19. Therefore computations on 1918 data were limited to these ranges.

The cross-sectional area of water below mean low tide was obtained for each range by planimeter measurement. The surface area of each segment, bounded by adjacent ranges and the intervening shore lines, was obtained by planimeter measurements of the 1938

reissue of the U. S. Coast and Geodetic Survey chart No. 495, published in August 1931. From these data, the volume of water in each segment at mean low tide was calculated by the use of Dobson's formula for reservoir capacities.[4] The difference in volume in any segment on different dates represents the amount of scour or silting which took place in this segment in the intervening period. The net result of scour and fill in all 12 segments represents the total accumulation or scour for the 20-mile section of river studied. Figures 2, 3, 4, and 5 were plotted to show comparative trends in deposition and scour on all ranges and in the enclosed segments between dates of survey. Cross sections of ranges 11, 12, 13, and 14 are shown as figures 6 and 7.

In addition, the annual reports of the Chief of Engineers, U. S. Army, from 1875 to date were reviewed in order to determine the effects of dredging on the amount and distribution of sediment.

Sediment Observations

At 3 to 8 points on each range, where the boat was stopped for sextant observations, a vertical sequence of sediment 1 to 24 feet in length was brought up on the sampling spud,[5] or in the coring pipe. The texture, color, estimated shell content, thickness of each distinctive layer, and other pertinent characteristics were recorded. These field records were subsequently plotted as columnar sections on the profile of the range.

Sampling

Altogether 28 samples from various parts of the area were collected for further study. In addition to samples from ranges, some samples were obtained in the Mattaponi and Pamunkey Rivers near West Point, in the mouths of the tributary streams, and in the mouths of minor bays and creeks in the middle portion of the area surveyed. No analyses have been made of these samples, as it has not yet become apparent that the results of such analyses would lead to any significant conclusions.

---

[4]Dobson, G. C. A Formula for Capacities of Reservoirs. Soil Conserv. 1: 7-9, 1936.

[5]Eakin, H. M. Silting of Reservoirs. U. S. Dept. Agr. Tech. Bull. 524: 27, 1936.

RESULTS OF 1938 INVESTIGATIONS

In the York River estuary, from range 6 (450 feet below West Point, Va.) to range 19 (about 6 miles above Yorktown, Va.), a distance of 19.41 miles, the total water volume below mean low tide was reduced from 1857 to 1911 and again from 1911 to 1938. The water volume at mean low tide was 227,780 acre-feet in 1857, as determined by the Dobson reservoir formula from hydrographic charts of that date. Similar computations of water volume were made from the data on the hydrographic chart for 1911 and from soundings made by the Section of Sedimentation Studies in November 1938. The water volume in 1857, the earliest date for which recorded data were available, was taken as a base, with which subsequent water volumes were compared to determine the net sediment accumulation since that date.

The results given in table 1 show an average reduction in volume (amount of sedimentation) of 104 acre-feet per year during the period 1857-1911, and 566 acre-feet per year during the period 1911-1938. Thus the indicated average rate of silting has been approximately 5 times as great during the 27 years following 1911 as it was during the 54 years preceding that date.

These rates of accumulation are only approximate, for they are based on essentially reconnaissance survey data. They are less exact than the rates ordinarily determined by the standard methods used in sedimentation surveys of reservoir and valley deposits. For example, the magnitude of error resulting from adjustments of data from surveys of different dates to the same mean low water datum is unknown. Extensive geodetic investigations would be required to determine whether any adjustments in mean low water datum of the several dates are required. Nevertheless, the fact that the surveys of the three dates show uniform trends and are checked by comparatively accurate soundings made along four of the ranges at a fourth date, 1918, indicates that the above figures are of the correct order of magnitude and that the indicated increase in the rate of silting in the last three decades over the earlier period is substantially correct.

The cross-sectional area of water below mean low tide has been plotted for each range for the years 1857, 1911, and 1938 (fig. 2). From figure 2 it is apparent that the cross-sectional area at every range was less in 1938 than in 1857, but that the decrease has not been uniform at all ranges. It is also apparent that the filling has not been a continuous process between these dates. Ranges 6, 7, and 11 show fill between 1857 and 1911 and scour since the latter date, whereas ranges 9, 15, 17, and 19 show scour between

FIGURE 2

YEAR OF SURVEY

1857 | 1911 | 1938 | 1857 | 1911 | 1918 | 1938 | 1857 | 1911 | 1918 | 1938 | 1857 | 1911 | 1938 | 1857 | 1911 | 1938 | 1857 | 1911 | 1938 | 1857 | 1911 | 1938 | 1857 | 1911 | 1938 | 1857 | 1911 | 1938 | 1857 | 1911 | 1918 | 1938 | 1857 | 1911 | 1918 | 1938

0
20,000
40,000
60,000
80,000
100,000
120,000
140,000
160,000
180,000

SQUARE FEET

R-6
R-7
R-8
R-9
R-10
R-11
R-12
R-13
R-14
R-15
R-17
R-18
R-19

LEGEND
FILL SCOUR

CROSS-SECTIONAL AREAS AT MEAN LOW TIDE ON RANGES ACROSS YORK RIVER, VIRGINIA

R-2522 *Revised 2-14-39*

Table 1.--Silting in the York River, Va., 1857-1938

Date	Water volume at date of survey	Cumulative volume of sediment deposited	Annual deposition since preceding survey	Cumulative loss of water volume	Annual loss of water volume since preceding survey[1]
	Acre-feet	Acre-feet	Acre-feet	Percent	Percent
1857.....	227,780	.....	.....	.....	.....
1911.....	222,189	5,591	104	2.45	0.05
1938.....	206,396	20,884	566	9.17	.25

[1]Based on water volume in 1857.

1857 and 1911 but fill since 1911. There appears, however, to be some orderly relation of scour and fill at the various ranges. This is more clearly indicated by figures 3 and 4, which show the average depth of deposit and scour at each range.

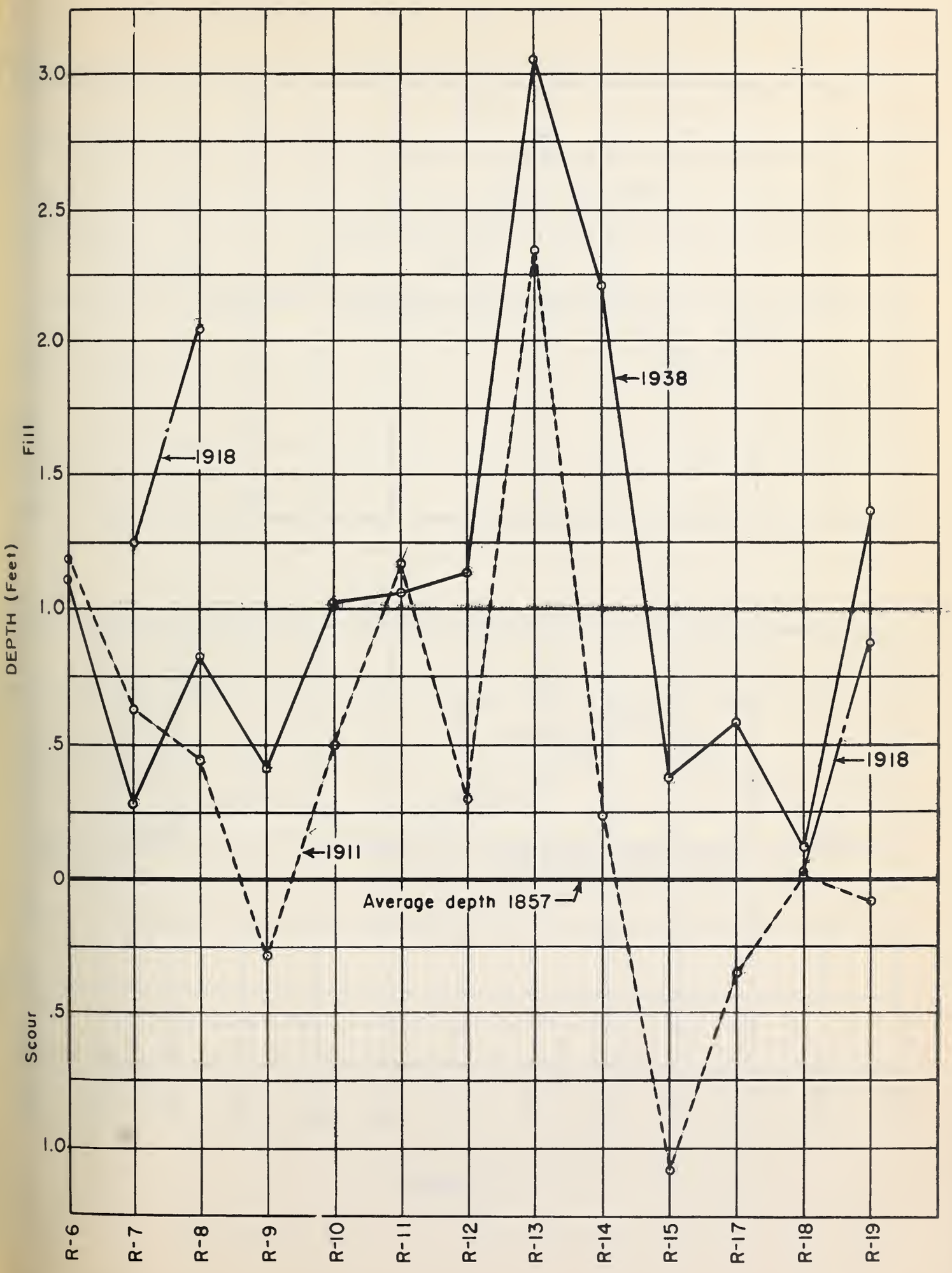
Between 1857 and 1911, there were two main areas of heaviest sediment accumulation, one at the head of the estuary between ranges 6 and 8, and one in the upper middle estuary between ranges 10 and 14. These areas of excessive accumulation were separated by an area of scour near range 9. A second and larger area of scour was located below range 14. Between 1911 and 1938 there were still two areas of filling and two of scour. These areas, however, coincide only partially with the areas of scour and fill between 1857 and 1911. The point of most rapid accumulation migrated downstream from range 13 to range 14, and sedimentation was also rapid at ranges 15 and 17, where, between 1857 and 1911, pronounced scouring occurred (fig. 4). In the estuary immediately below West Point, accumulation between 1857 and 1911 was followed by scour between 1911 and 1938. Data from the 1918 soundings at ranges 7 and 8 indicate that accumulation continued at these ranges until 1918 and that the scour has occurred since that date. In this area, however, there has been some modification as a result of dredging. Consequently, trends indicated by comparing sounding measurements at those upper ranges should be accepted with reservations, pending more complete information concerning dredging operations in this section.

The deposition and scour in each segment are shown in figure 5. This figure shows more clearly than figures 2 and 3 the locus of most active deposition between the various dates of survey. The rapid accumulation from 1857 to 1911 and from 1911 to 1938 in the upper middle of the estuary is well illustrated, as is the apparent movement of the locus of most active deposition down the estuary; i.e., from segment 8 to segments 9 and 10.

Study of annual reports of the Chief of Engineers, U. S. Army, and local inquiry indicate that material dredged in the upper York River was deposited on shallow areas or shoals within the same section of the river. Hence little or no net gain or loss with respect to the amount of silting has been caused by dredging operations, although the fill and scour in individual segments above the mouth of Poropotank Creek may have been affected. The total amount dredged and redredged during the period 1880-1938 was 992 acre-feet, compared with net deposition of 5,591 acre-feet during the period 1857-1911 and 15,293 acre-feet during the period 1911-1938.

Of the dredged material 36 acre-feet was excavated in the channel opposite the mouth of Poropotank Creek in 1881, 302 acre-feet was excavated from the West Point turning basin during the period 1927-1936, and the remainder, 654 acre-feet, was dredged

AVERAGE DEPTH OF DEPOSIT AND SCOUR ON RANGES ACROSS YORK RIVER, VIRGINIA



Revised 2·14·39

R-2522

AVERAGE DEPTH OF DEPOSIT AND SCOUR ON RANGES ACROSS YORK RIVER, VIRGINIA

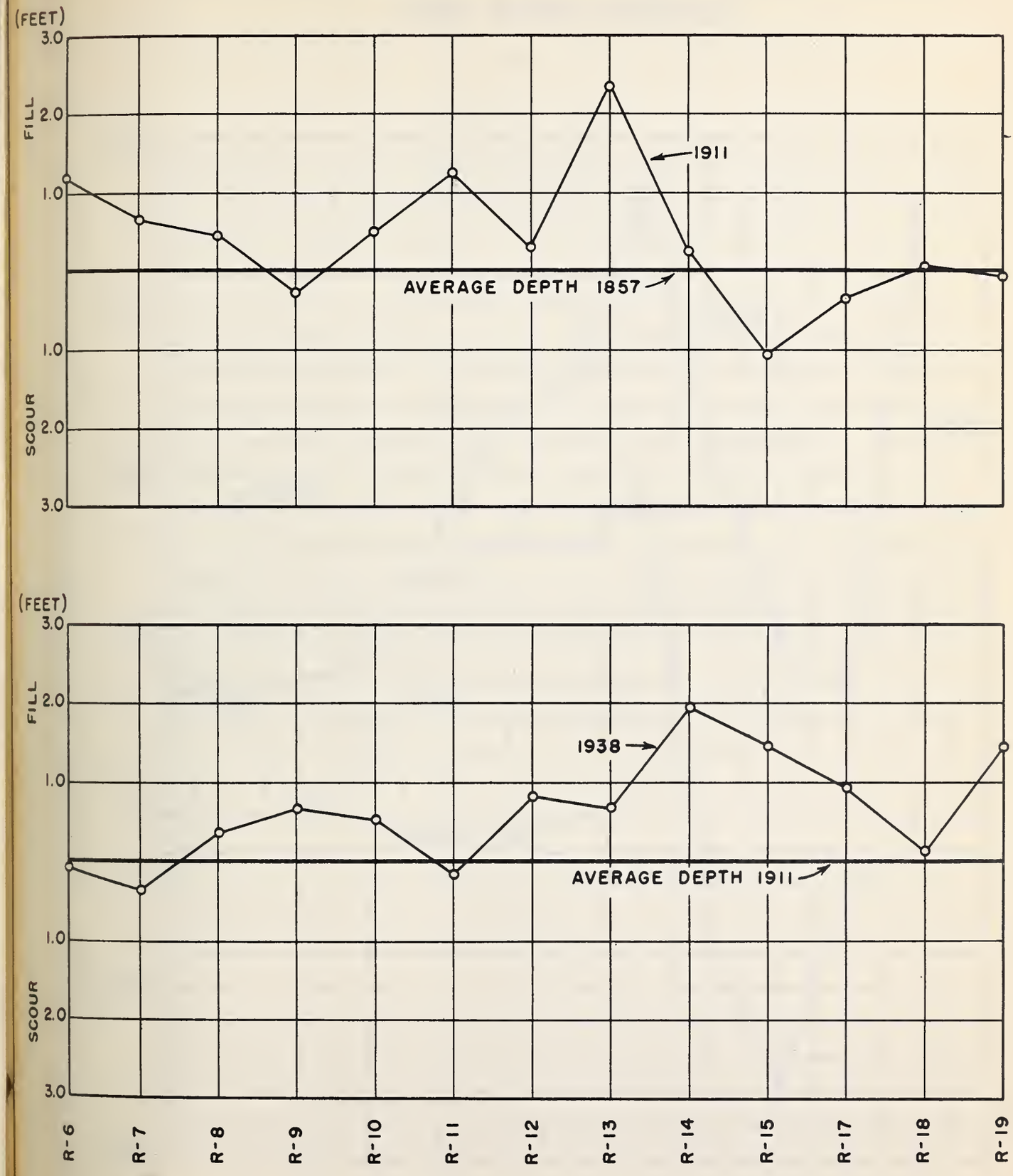


FIGURE - 4

from the channel on West Point Bar. (Information obtained from the U. S. Army Engineers indicates that a large part, if not all, of the material dredged from the West Point turning basin was deposited above range 6 near the mouth of Thoroughfare Creek.)

Field examination indicates that the present surface sediment over most of the estuary is dominantly gray silty clay. Near the channel the deposits contain a small percentage of sand. Locally, shell accumulations, 6 to 10 inches in thickness, form "hard" bottom above the silty clay. No systematic lateral variations in texture were found, but it was noted that the compactness of the sediment, as measured by the depth of penetration of the spud, was greater in the lower part of the estuary than in the middle and upper sections. In the estuary deposits, no definite horizon was identified which might be considered the bottom of the estuary at the time culturally accelerated erosion began in the tributary drainage area. Thus far, a study of plotted columnar sections of sediment has failed to reveal any significant correlations between the character of fill and the rates of fill at particular points. Study of the sections has not, however, progressed far enough to rule out the possibility that some trends exist.

So far no sediment analyses have been made. It has not yet become apparent that valuable information would be obtained from the rather tedious analyses which would be required for most of the sediment. Without an exhaustive study of sediment and sediment sources throughout the whole drainage area it is extremely unlikely that either mechanical or mineralogical analyses of the deposits in the York River would afford any basis for interpretations or deductions regarding sediment origin.

RANGE No. 11

WIDTH (Feet)

RIGHT BANK

LEFT BANK

800 1600 2400 3200 4000 4800 5600 6400 7200 8000 8800 9600

0.0 8.0 16.0 24.0 32.0

DEPTH AT MEAN LOW TIDE (Feet)

1938

1911

1857

RANGE No. 12

RIGHT BANK

LEFT BANK

0.0 8.0 16.0 24.0 32.0

DEPTH AT MEAN LOW TIDE (Feet)

1911

1938

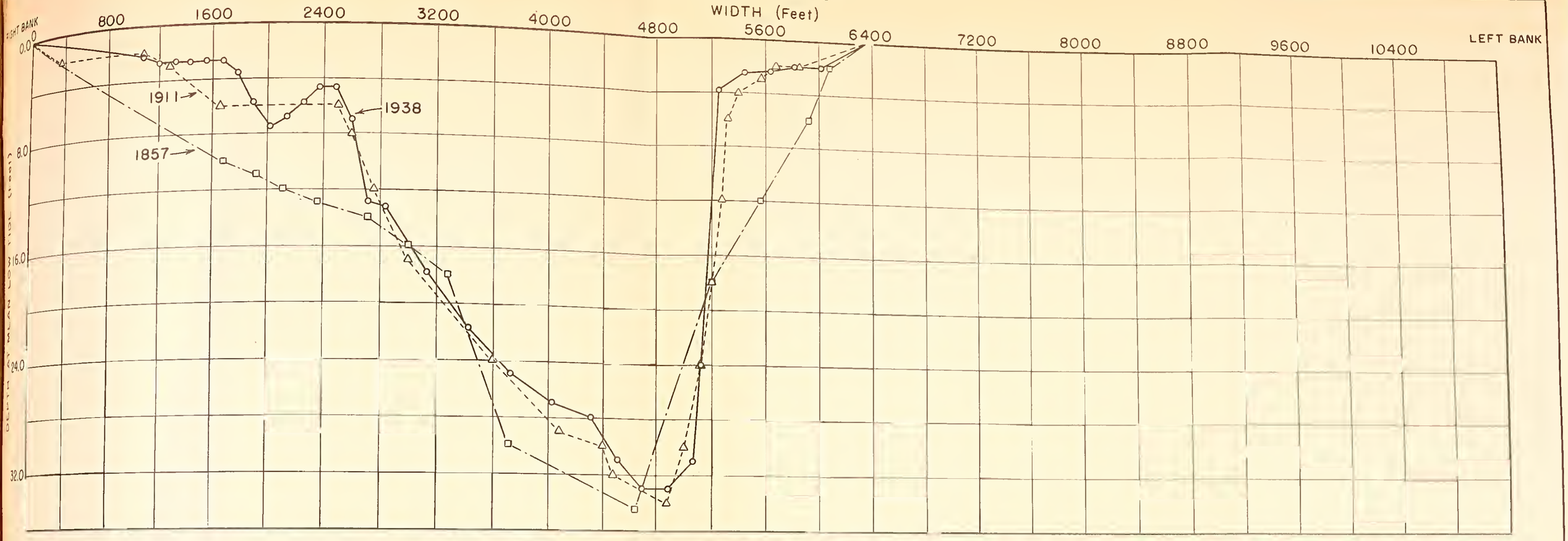
1857

YORK RIVER
CROSS - SECTIONS

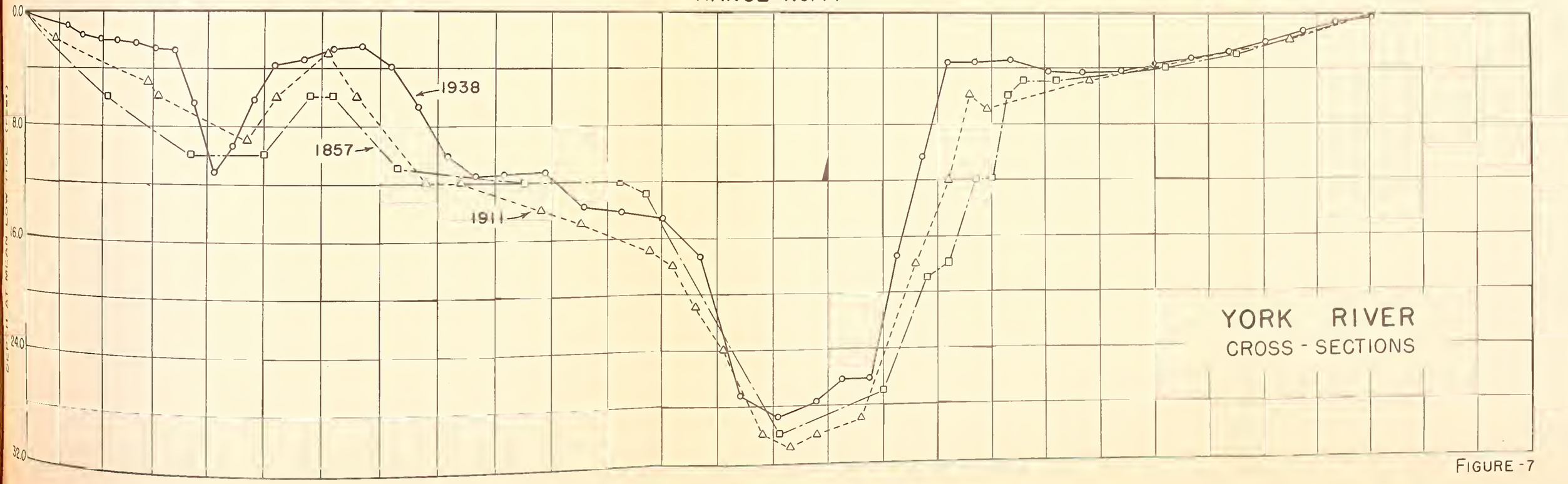
FIGURE - 6

2-14-39 0-2513

RANGE No. 13



RANGE No. 14



YORK RIVER
CROSS - SECTIONS

FIGURE - 7

2-15-39 0-2513